

IN THE SPECIFICATION:

Paragraph beginning at line 3 of page 1 has been amended as follows:

The present invention relates to an electrical property evaluation apparatus for measuring samples ~~including~~, such as samples having a magnetoresistive effect device on a micro-scale area thereof, and evaluating electrical properties thereof.

Paragraph beginning at line 19 of page 5 has been amended as follows:

The electrical property evaluation apparatus of the invention may be an electrical property evaluation apparatus for measuring an electrical property of an object to be measured, ~~including~~; the apparatus including a magnetic field generating mechanism for generating a magnetic field in a target area on the object; a magnetic sensor for measuring the magnetic field near the target area; a contact having a conducting probe, the contact being supported so that the probe can be brought into contact with the target area; a voltage source for applying a voltage to the probe; and an electrical property measuring section for measuring a current or an electrical resistance between the probe and the object in contact with each other.

Paragraph beginning at line 6 of page 7 has been amended as follows:

The electrical property evaluation apparatus of the invention may be the above electrical property evaluation apparatus, wherein the magnetic field generating mechanism includes a pair of magnetic field coils, each having a magnetic pole member, the magnetic field coils being located opposite to each other, and the magnetic sensor and contact are located in a center location between the pair of magnetic pole members.

Paragraph beginning at line 13 of page 7 has been amended as follows:

In the electrical property evaluation apparatus according to the invention, ~~one pair of the~~ two magnetic field coils are located opposite to each other and the magnetic sensor and contact are located in the center location between the paired magnetic field coils. Therefore, the gradient distribution of the strength of a magnetic field generated by the paired magnetic field coils reaches the minimum thereof in the target area and a desired magnetic field can be easily obtained with high accuracy. ~~Incidentally~~ Moreover, the magnetic field generating mechanism can be arranged easily, because the magnetic field which the pair of magnetic field

coils generate with respect to an object to be measured can be controlled only by a current flowing through the magnetic field coils.

Paragraph beginning at line 8 of page 9 has been amended as follows:

~~The In the electrical property evaluation apparatus of the invention, is the above electrical property evaluation apparatus, wherein the contact is a cantilever, and which the apparatus further includes:~~ includes a bending measurement mechanism for measuring an amount of bending of the cantilever when the probe is brought into contact with the object to be measured; and a control section for controlling the moving mechanism so as to make the bending amount obtained in the bending measurement mechanism constant.

Paragraph beginning at line 16 of page 9 has been amended as follows:

In the electrical property evaluation apparatus according to the invention, the bending amount of the cantilever can be measured with the measurement mechanism ~~in~~ while scanning an object to be measured with the cantilever. Therefore, it is possible to measure up and down displacement amounts of the cantilever with respect to the surface profile

of the object. By measuring the up and down displacement amounts, the cantilever can be moved up and down so as to keep the displacement amounts constant, and also the surface profile of the object can be easily observed directly based on the displacement amounts. This allows the smooth scanning of the object and the scanning the same place while applying a bias voltage. Therefore, an electrical property distribution for the object can be evaluated for the scanned region.

Paragraph beginning at line 7 of page 11 has been amended as follows:

Fig. 1 is a block diagram showing an electrical property evaluation apparatus according to an embodiment of the invention. The electrical property evaluation apparatus 1 shown in Fig. 1 includes a probe microscope measurement section 2 for measuring electrical properties of a sample (an object to be measured) A with a magnetic field applied thereto. The probe microscope measurement section 2 ~~includes~~ includes a pair of magnetic field coils (a magnetic field generating mechanism) 10 for generating a magnetic field in a target area on the sample A; a magnetic sensor 11 for measuring the magnetic field near the target area; and a cantilever (contact) 21 which has a conducting probe 21a and is so supported that the probe 21a can be brought into contact

with the target area. The probe 21a is formed from a material, such as silicon and silicon nitride, which is coated with a conducting material, such as gold, platinum, and diamond-like carbon. Also the probe 21a may be made from a hard conducting material, such as carbon nanotube, and diamond single crystal.

Paragraph beginning at line 11 of page 12 has been amended as follows:

The sample table 20 is a stage having a top surface on which the sample A can be fixed, and the table is movable in X and Y directions. The sample table 20 is arranged so as to move the sample A to the center location between a pair of magnetic pole members 10a. The sample A is ~~to be~~ electrically connected during use of the apparatus with a current amplifier 25 through a the bias voltage source 26 for applying a bias voltage to the current amplifier 25. The cantilever 21 is shaped into a lever form, and the cantilever is formed from a material, e.g., silicon and silicon nitride. Further, on the top surface of the cantilever 21 there is, as a coating, a conducting material of gold, platinum, a carbon-based ~~one~~ material, e.g., diamond-like carbon, etc. The cantilever .21 is mechanically coupled to the three-dimensional scanner 22, and therefore the cantilever 21 is so arranged that it can be

finely moved by the scanner 22 relative to the sample A in all directions, i.e., up and down, right and left, and back and forth. More specifically, the sample A is moved by the sample table 20 so that the cantilever 21 is located over a target area on the sample A, and then the position of the cantilever 21 is controlled by the three-dimensional scanner 22 with high accuracy. Also, one end of the cantilever 21 is electrically connected with the current amplifier 25.

Paragraph beginning at line 8 of page 13 has been amended as follows:

Because the current amplifier 25 is electrically connected with the cantilever 21 and the sample A as described above, a circuit B is formed between them when the probe 21a of the cantilever 21 is brought into contact with the sample A. Particularly, the probe 21a serves as a switch. The current amplifier 25 has the function of amplifying a current generated in the sample A to send the amplified current to the system controller 30 when a bias voltage is applied between the sample A and probe 21a according to the bias voltage source 26. The system controller 30 is connected with a display section 30a for displaying the current value. In other words, the cantilever 21, current amplifier 25, bias voltage source 26, system controller 30, display section 30a,

and circuit B constitute an electrical property measuring section 40 for measuring the current or electrical resistance between the probe 21a and sample A.

Paragraph beginning at line 24 of page 13 has been amended as follows:

A laser source 23 and an optical location detector 24 are provided so as to move together with the three-dimensional scanner ~~22~~; 22, and the laser source 23 is disposed above the cantilever 21 so as to irradiate the rear of the probe 21a of the cantilever 21 with a laser beam. The optical location detector 24 has the function of detecting the laser beam reflected off the rear of the cantilever 21 as a reflected light. The value detected by the optical location detector 24 is entered into a Z servo control section (control section) 31. The Z servo control section 31 has the function of operating the three-dimensional scanner 22 based on the detected value entered therein to control the cantilever 21 in the Z direction, i.e., the height of the cantilever 21 from the sample A. This allows controlling the amount of the bending of the cantilever 21 so that it is held constant at all times. The laser source 23 and optical location detector 24 constitute a bending measurement mechanism 41 for measuring

the amount of bending of the cantilever 21 when the probe 21a of the cantilever 21 is brought into contact with the sample A.

Paragraph beginning at line 6 of page 15 has been amended as follows:

Herein, as shown in Fig. 2A, ~~one pair of~~ two magnetic field coils 10, each of which is configured by winding a coil 10b around a an elongate magnetic pole member 10a shaped into a strip form, are located in spaced-apart relation opposite to each other and inclined relative ~~provided with an inclination~~ to the surface of the sample A with the tips of the magnetic pole members 10a facing to the target area on the sample A. Further, as shown in Fig. 2B, in the center region or location of the pair of magnetic pole members 10a is provided ~~with a~~ the magnetic sensor 11 for measuring the density of magnetic flux of the cantilever 21, a Hall device, etc.

Paragraph beginning at line 25 of page 15 has been amended as follows:

The magnetic sensor 11 is electrically connected with the magnetic field controller 16. The magnetic sensor 11 ~~has the function of measuring~~ measures a magnetic field generated by the magnetic field coils 10 ~~to enter the~~ and

produces a measured signal ~~into~~ that is supplied to the magnetic field controller 16. The magnetic field controller 16 ~~has the function of sending~~ sends a control signal to the coil power source 15 for magnetic field generation based on the ~~entered~~ measured signal. The coil power source 15 for magnetic field generation has the function of flowing a current through both the magnetic field coils 10 based on the received control signal. In other words, the magnetic sensor 11, coil power source 15 for magnetic field generation, and magnetic field controller 16 control the magnetic field generated by the magnetic field coils 10 so that it has a given the desired strength. In addition, the magnetic field controller 16 is connected with the system controller 30 and controls the magnetic field based on the program preset in the system controller 30 so as to supply the sample A with the magnetic field with a given strength, a given polarity, a given variable amount, etc.

Paragraph beginning at line 7 of page 17 has been amended as follows:

As shown in Figs. 3 and 4, the sample A is a magnetoresistive effect device, which is formed in a ~~three-layers~~ three-layer structure having a ferromagnetic free layer 50, a fixed layer 51, and a nonmagnetic layer 52 of an

insulator interposed between the free layer 50 and fixed layer 51. The free layer 50 is formed from a ferromagnetic material such that the direction of the internal magnetic field (indicated by a black arrow) changes in response to the direction of the external magnetic field (indicated by a white arrow) of, for example, a few hundreds gaussses. In contrast, the fixed layer 51 is formed from a ferromagnetic material such that the direction of the internal magnetic field is not affected by a weak magnetic field of a few hundreds gaussses. Incidentally, it is assumed that the direction of the internal magnetic field of the free layer 50 is the same as the direction of the internal magnetic field of the fixed layer 51 in a pre-measurement condition.

Paragraph beginning at line 21 of page 18 has been amended as follows:

Then, while keeping the cantilever 21 in the same position, an external magnetic field is applied to the sample A in a direction (represented by the ~~unfilled~~ white arrow) opposite to the internal magnetic field direction (represented by the black arrow) of the fixed layer 51 by the magnetic field coils 10, as shown in Fig. 4. This changes the internal magnetic field direction of the free layer 50 into the same direction as that of the external magnetic field (represented

by the black arrow). In other words, the magnetic field is generated so as to make the internal magnetic field directions of the free layer 50 and fixed layer 51 opposite to each other. When such condition is achieved, the value of the current flowing through the target area on the sample A is gauged or measured by the system controller 30.

Paragraph beginning at line 19 of page 19 has been amended as follows:

~~Like this~~ In this manner, the value of the current flowing the sample A varies according to the direction of the magnetic field generated by the magnetic field coils 10. These current values are gauged or measured by the system controller 30 to analyze the difference therebetween, whereby various kinds of data, such as a current image, an electrical conductivity distribution, a current characteristic, and a magnetoresistance image, can be obtained in a target area on the sample A, i.e., a micro-scale area the probe 21a is in contact with and therefore the electrical properties of the sample A can be evaluated.

Paragraph beginning at line 4 of page 20 has been amended as follows:

The strength and direction of the magnetic ~~field~~ fields that the magnetic field coils 10 generate are controlled by a program preset in the system controller 30 and as such, the value of the current flowing through the sample A can be gauged or measured while changing the strength and direction of the magnetic field easily. Thus, the relations of various kinds of electrical property values including a current value, an electrical property distribution for the sample A, etc., with respect to the strength of the external magnetic field can be obtained easily.

Paragraph beginning at line 23 of page 20 has been amended as follows:

More specifically, in the condition where a current value in the sample A is gauged as described above, the system controller 30 controls the XY scanning control section 32 to operate the three-dimensional scanner 22, whereby the probe 21a at the tip of the cantilever 21 is moved with the probe in contact with the sample A. In other words, the cantilever 21 moves while scanning the sample A. In moving, the cantilever 21 is displaced up and down according to the surface profile of the sample A. The up and down displacement of the

cantilever 21 makes a variation of the reflection angle of the laser beam which the laser source 23 ~~launches~~ directs toward the rear of the cantilever 21. The amount of the variation of the reflected light is detected by the optical location detector 24 to be sent to the Z servo control section 31. The Z servo control section 31 sends a control signal to the three-dimensional scanner 22 so as to control the three-dimensional scanner 22 in up and down directions based on the detected value and as such, the cantilever 21 is caused to scan the sample A in the condition where it is kept at a fixed height from the sample A.

Paragraph beginning at line 22 of page 22 has been amended as follows:

Also, because ~~one pair~~ two of the magnetic field coils 10 are located opposite to each other and the magnetic sensor 11 and cantilever 21 are located in a center location between the paired magnetic field coils 10, the gradient distribution of the strength of a magnetic field generated by the paired magnetic field coils 10 reaches the minimum thereof in the target area on the sample A and therefore a desired magnetic field can be easily obtained with high accuracy.

Paragraph beginning at line 22 of page 23 has been amended as follows:

In addition, an optical lever-type bending measurement mechanism 41 including a laser source 23 and a an optical location detector 24 has been adopted as a measurement mechanism for a bending amount of the cantilever 21 in the embodiment. However, the invention is not so limited, and it is essential only that the apparatus has an arrangement which allows the measurement of the bending amount of the cantilever 21. For example, the cantilever may be arranged as a self-sensing type cantilever capable of detecting the bending amount by itself.